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PERFORMANCE EVALUATION OF INTERLEAVER IN RS CODES USING 16 PSK AND QPSK

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Abstract- Forward Error correction techniques are used for error correction. In this paper we have used Reed- Solomon Codes using interleaver for error correction and detection .In these types of codes redundant information is added at the end of message to detect and correct error. R-S Codes are used to recover original codeword from corrupted received word , and interleaver help in spreading the error. In this paper we develop a Simulation program using MATLAB for Reed -Solomon Codes using interleaver and modulation schemes i.e. 16 PSK and QPSK using AWGN
Keywords- RS codes, Interleaver, 16 PSK, QPSK(4 QAM), AWGN

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Introduction

In communication systems, our main purpose is to transmit a message and receive it with no error. If there is an error during transmission, the need of retransmission of message over noisy channel is required [1]. With regard to this problem Forward Error Correction (FEC) is introduced, known as Reed-Solomon codes. In these types of codes we systematically add redundancy at the end of the message so as to enable the correct retrieval of message despite errors in the received sequences. This eliminates the requirement of retransmitting the message.

Reed-Solomon codes are the most commonly used in all forms of transmission and data storage for forward Error correction (FEC). Many algorithm for this code have been constructed and each of them have their own properties such as correcting errors beyond their error correcting capability, low complexity, lower probability of error . The rest of this paper is organized as follows i.e. Section 2 covers Reed-Solomon codes and describes the simulation process using MATLAB simulation. Section 3 shows the result obtained from the simulation and discussion are made. Conclusions are drawn and future work of this project is outlined.

Reed-Solomon Codes

Properties of R-S codes

Reed-Solomon codes is a systematic linear block code, means that the message to be transmitted is divided into separate blocks of data. Each block has parity protection information added to it to form a self-contained code word. It is a systematic code where the encoding process does not alter the message symbols and the protection symbols are added as a separate part of the block [1].

Reed-Solomon codes is also a linear code and cyclic. It is particularly good at dealing with bursts of errors because, although a symbol may have all its bits in error, this counts as only one symbol error in terms of the correction capability . Thus, a R-S (n, k) code implies that the encoder takes in k symbols and adds (n − k) parity symbols to make it an n-symbol code word.

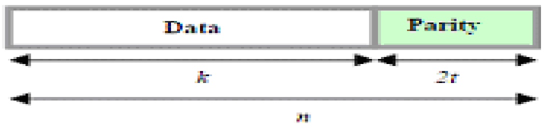

Fig. 1 - A typical R-S Codeword

Reed-Solomon codes are based on Galois Fields. Also, n = 2m-1 where m is the number of bits in a symbol. There are (n-k) parity symbols and t symbol errors can be corrected in a block, where t= (n-k)/2 [2]
R-S (n, k) codes on m-bit symbols exist for all n and k for which
0 < k < n < 2m + 2 (1)
where k is the number of data symbols being encoded, and n is the total number of code symbols in the encoded block. For the most conventional R-S (n, k) code,
(n ,k) = (2m - 1, 2m - 1 - 2t) (2)
where t is the symbol-error correcting capability of the code, and n-k = 2t is the number of parity symbols. An extended RS code can be made up with n = 2m or
n = 2m + 1. Reed-Solomon (R-S) codes achieve the largest possible code minimum distance for any linear code with the same encoder input and output block lengths. For non-binary codes, the distance between two code words is defined as the number of symbols in which the sequences differ. For Reed-Solomon codes the code minimum distance is given by (3)
dmin = n - k + 1 (3)
The code is capable of correcting any combination of t or fewer errors, where

$$t = \left[\frac{d_{min}-1}{2}\right] = \left[\frac{n-k}{2}\right] \qquad (4)$$

RS Encoding
Consider the finite field with q elements, GF (2m). The message to be transmitted, f, consists of k elements of GF (2m) [2].

f =(fo, f1, …..f k-1) , fi € GF(2m) (5)

The message symbol can be considered to be the coefficients of a degree k - 1 message polynomial which to be encoded,

$$f(x) = f_0 + f_1x + f_2x^2 + \dots + f_{k-1}x^{k-1} \qquad (6)$$

While the coefficients of the remainder is 2t parity-check digits, where

$$b(x) = b_0 + b_1x + \dots + b_{2t-1}x^{2t-1} \; (7)$$

Hence, the output codeword to be transmitted is

$$\begin{aligned} v(x) &= f(x) + b(x) \\ &= v_0 + v_1x + v_2x^2 + \dots + v_{n-1}x^{n-1} \qquad (8) \end{aligned}$$

RS Decoding
During transmission, any codeword received at the receiver is assumed to be corrupted by the noise in the channel that introduces errors in the communication system [2]. Let say if the received corrupted-codeword is assume to be r(x), hence we have
r(x) = c(x) + e(x) (9)
where c(x) is the original codeword and e(x) is the error pattern polynomial and can be described as

$$e(x) = e_{n-1}x^{n-1} + \dots + e_1x + e_0 \qquad (10)$$

Each of the coefficients e n-1…e0 is an m-bit error value, represented by an element GF(2m), with the errors position in the codeword being determined by the degree of x for that term. if more than t = (n-k)/2 of the e values are nonzero, then the correction capability of the code is exceeded and the errors are not correctable. However, Reed-Solomon algorithm still allow one to detect if there are more than t errors and for this cases, the codeword is declared un- correctable.

Interleaver
An interleaving is usually added between two codes to spread burst errors across a wider range. An Interleaver improves the error rate in communication system whose channel produces a burst error [9] ,[10] . This method is implemented in such a manner that an inter-carrier Interleaver rearranges carrier numbers according to an error correction method, Interleaving and De Interleaving is useful for reducing errors caused by burst errors in communication system. Figure 2 shows the basic interleaving process.

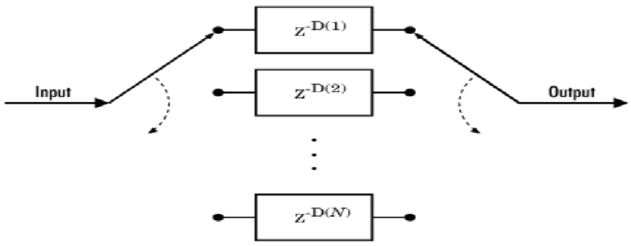

Fig. 2 - The basic Interleaving process

Modulation
Modulation is the process of varying one or more properties of a high-frequency periodic waveform, called the carrier signal, with a modulating signal which typically contains information to be transmitted. In telecommunications, modulation is the process of conveying a message signal. Modulating a sine-wave carrier makes it possible to keep the frequency content of the transferred signal as close as possible to the centre frequency (typically the carrier frequency) of the passband. A device that performs modulation is known as a modulator and a device that performs the inverse operation of modulation is known as a demodulator (sometimes detector or demod)

PSK Modulation
Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave).
PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal.
In PSK, the constellation points chosen are usually positioned with uniform angular spacing around a circle. This gives maximum phase-separation between adjacent points and thus the best im-

munity to corruption. They are positioned on a circle so that they can all be transmitted with the same energy.

QPSK Modulation

This type of modulation is also known as quaternary PSK, quadriphase PSK, 4-PSK, or 4-QAM. QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with gray coding to minimize the bit error rate (BER). QPSK transmits twice the data rate in a given bandwidth than at the same BER.
QPSK is viewed as a quaternary modulation, it is easier to see it as two independently modulated quadrature carriers. With this interpretation, the even (or odd) bits are used to modulate the in-phase component of the carrier, while the odd (or even) bits are used to modulate the quadrature-phase component of the carrier.

MATLAB Simulation

The simulation tasks of this paper includes implementing the coding and decoding of Reed-Solomon codes through PSK and QPSK modulation scheme in AWGN channel and the simulation work was accomplished using MATLAB. Figure 3 shows the block diagram of the system.

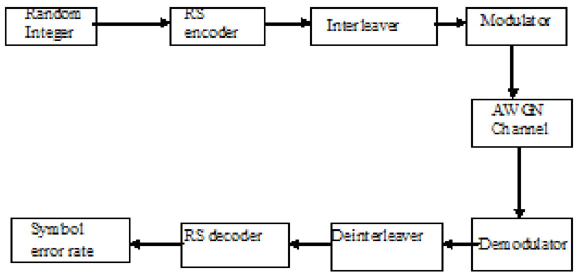

Fig. 3 - Block Diagram of the system

Result and Discussion

In this section, the MATLAB function will be verified by simulating an R-S code with 16 PSK and QPSK (4-QAM) modulation scheme system in AWGN channel.
R-S (15, 11) code is selected and , defined over GF(16), each symbol of the code consists of four bits. Figure 4, 5 display the simulated results of 16PSK and QPSK scheme respectively and Table 3.1 shows the performance comparison results for RS Codes with 16 PSK and QPSK(4-QAM).

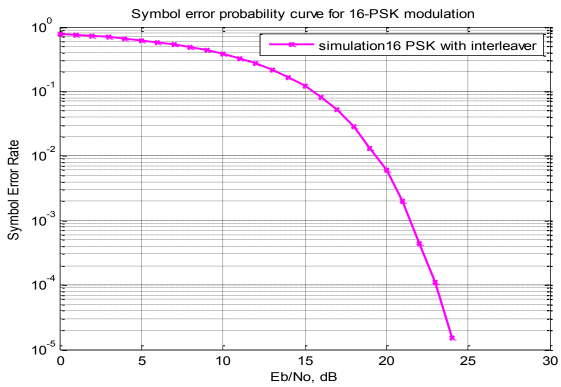

Fig. 4 - SER of R-S(15,11,) 16 PSK scheme in AWGN channel

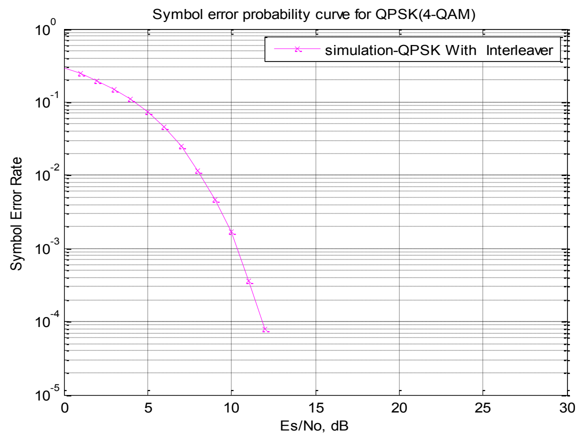

Fig. 5 - SER of R-S(15 ,11) QPSK scheme in AWGN channel

Table 1 Performance comparison results for RS Codes with 16 PSK and QPSK(4-QAM) Result

Es/No(db)	0	4	8	12
Simulated 16 PSK SER	0.7778	0.661	0.4887	0.2722
Simulated QPSK SER	0.2933	0.1118	0.01166	0.0539

Conclusion

The proposed program based on MATLAB simulation used to calculate the SER performance .
From the simulation results it has proved that QPSK performs better than 16 PSK with interleaver . As ES/NO increases Symbol error rate decreases for QPSK in comparison with 16-PSK.

Future Work

RS codes performance can be evaluated using different modulation schemes and also by utilising different codes like LDPC , Hamming codes and Convolutional codes.

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